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A Hybrid Active Power Filter Using Artificial Neural Networks to Remove Harmonics from Distorted Mains

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***Abstract**: A description of the dynamic neural network-controlled hybrid active power filter (HAPF) is provided for harmonic correction during source voltage and load current fluctuations. A neural network-based controller operates to extract current essentials from non-sinusoidal and unbalanced currents of the examined supply system. The presented compensation system merges shunt active and shunt passive filter mechanisms to achieve superior performance. The analysis of a three-phase hybrid active power filter occurs within MATLAB/SIMULINK both for balanced and unbalanced loads and unbalanced and distorted sources. The methodology validation took place through the complete simulation level findings presentation.*

***Keywords**: Artificial Neural Network, THD, PI controller, hybrid active power filter*

I. Introduction

The use of power electronics-based nonlinear loads has caused a continuous deterioration of power quality during the last few years. The international standards define power quality standards through the maintenance of pure sinusoidal waves between the current and voltage waveforms that stay perfectly sinusoidal. Power quality issues emerge whenever sinusoidal waveform distortions occur in voltage or current or any frequency deviation occurs. Commercial and industrial applications and utility interfaces drives frequent occurrences of power quality problems. Such appliances generate both harmonics along with reactive power.

The IEEE 519 harmonic standard emphasizes dominant harmonic correction which requires THD levels below 5% [1]. The reduction of harmonic distortion receives support from active and passive filters as two separate filtering solutions. The basic operational approach to troubleshoot harmonic distortion and enhance power factor at power system utilities uses passive filtering. The passive filter presents multiple fundamental limitations because its size is cumbersome and it faces tuning problems related to tolerance while needing fixed L & C values for specific compensation settings. Furthermore, its construction remains simple but expensive. Active Power Filters (APF) serve as the solution to resolve this problem.

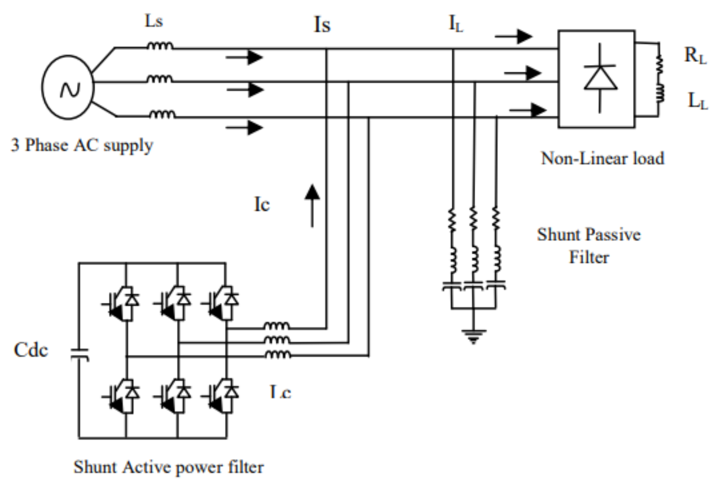

Fig 1: Hybrid filter configuration

Within power systems active power filters represent an excellent harmonic current reduction solution due to their small dimensions together with automatic operation and no need for tuning adjustments. A harmonic current source functions through active power filters for successful compensation of reactive power and harmonic currents. It generates harmonic current with equal magnitude while being out of phase with the load to enter the ac system [2]. The hybrid active power filter dominates harmonics solutions in figure 1 because its complex system and economical parameter management makes it the preferred selection.

II. Proposed Topology

A prototype design of three-phase three-wire hybrid power filter appears in Figure 2. The shunt active power filter generates compensatory current that operates in an opposite phase. A power circuit of IGBT-based three-phase voltage source inverter with DC storage capacitor has been proposed for APF applications to enhance non-linear and balanced and unbalanced load compensation. Reference current generation through the neutral network controller works together with DC voltage management implemented by the PI controller in active power filter control methods.

An artificial neural network uses three adaptive linear neurons to extract necessary elements from three phase voltages present in non-sinusoidal supplies. Active capacitors serve to maintain the dc voltage ripple between 1 and 4% of its predetermined range. Such capacitors should possess strength to endure maximum voltage requirements. The active filter operates across different modes to provide compensation current for eliminating or reducing harmonic currents in order to improve power quality. The power quality receives enhancement when the compensatory current is injected. The precision of active power filters depends heavily on the method used for reference current computation.

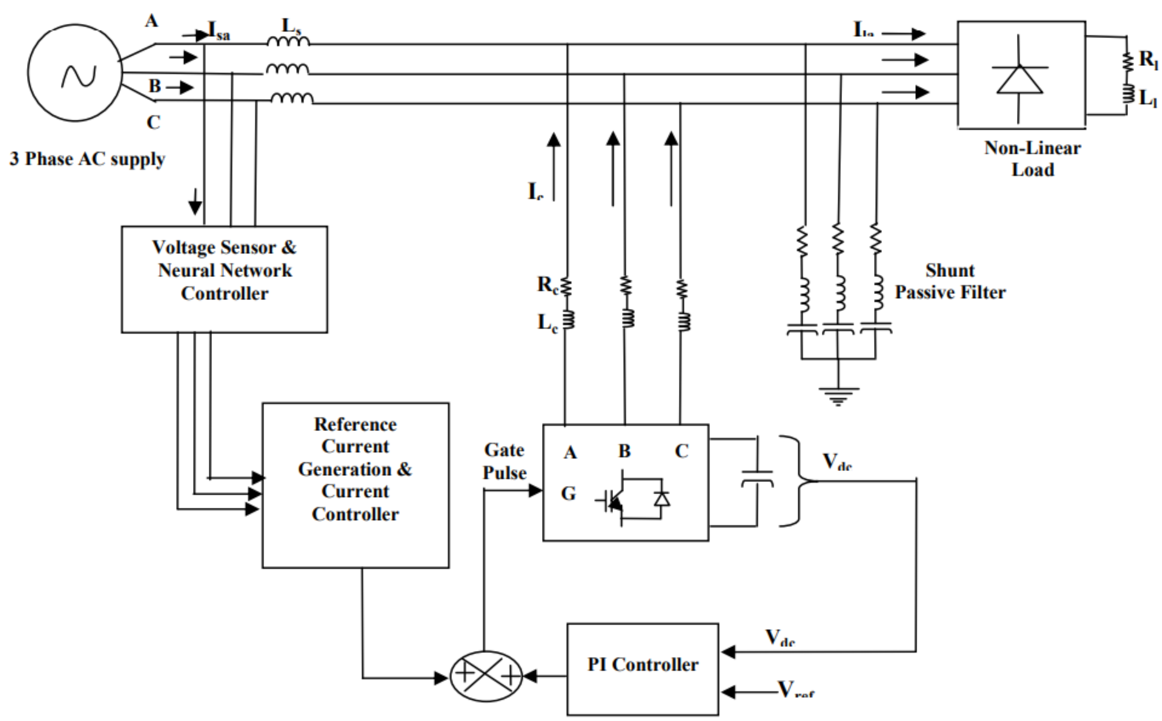

Fig 2: Shunt active power filter proposed topology

III. Control Strategy

The control scheme performs multiple functions as shown in Figure 3 where it keeps up the supply current's sinusoidal waveform then detects harmonics before controlling the DC voltage and supplying compensating power to the system while also giving out harmonic currents to the three-phase non-linear load. Operation of the HSAPF control scheme becomes necessary. The correct response of APF depends on extracting current fundamental components from non-sinusoidal input signals together with reference current generation and DC voltage regulation and the supply of compensatory currents [10]. Different regulating strategies are necessary to complete these duties successfully.

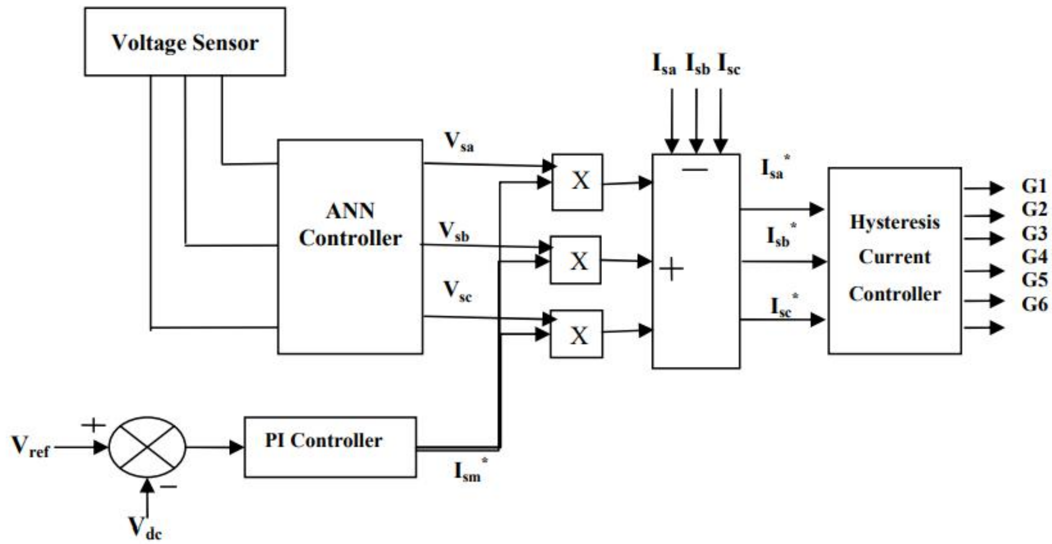

Fig 3: Control strategy for shunt active power filter schematic diagram

IV. Neural Network Controller

The problem of deriving vital information from transformed current or voltage waveforms represents a critical assessment method that determines power quality performance. Producing high-quality power supply electricity depends on precise estimation or extraction of both fundamental time-varying components and their phase angle magnitudes. Active power filters serve to decrease harmonic elements in power systems. The methodology depends on an ANN controller to realize harmonic estimation. The authors choose ANN due to its demonstrated superiority thus implementing this model for their research. The previously proposed actual conditions make traditional fundamental component separation through low pass filters non-effective.

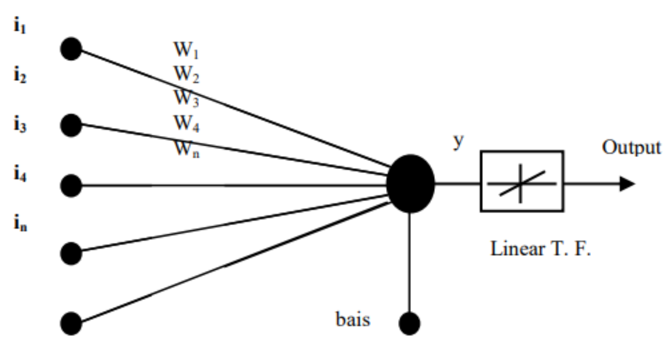

Fig 4: Internal blocks of proposed Neural Network

V. Conclusion

The estimation of the size and cost reduction of the active filtering unit with the addition of passive tuned filters for partial compensation has been done in this article. Variable VAR compensation of the passive filters has been estimated. A new strategy based on clever brain processes has been put forth. MATLAB simulation simulations were used to confirm the suggested ANN's performance. The suggested controller provides precise supply. The estimation confirms that the ANN control scheme-based shunt active filtering system may be made to be very cost-effective in real-world applications for improving power quality in retrofit systems.

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